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# Occupational Screening for Latent Tuberculosis Infection

Rapid Review

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# Abbreviations

| | |
|---|---|
| **BIA** | budget impact analysis |
| **HCW** | health care worker |
| **ICER** | incremental cost-effectiveness ratio |
| **LTBI** | latent tuberculosis infection |
| **QALY** | quality-adjusted life-year |
| **QFT** | QuantiFERON-TB Gold In-Tube test |
| **TB** | tuberculosis |
| **TST** | tuberculosis skin test |

## Key Message

In people at risk of occupational exposure to tuberculosis, targeted testing for latent tuberculosis infection (e.g., testing for high-risk individuals, testing after tuberculosis exposure) appears to be more cost-effective than repeated testing, such as testing once a year or every 3 years (findings based on 2 economic evaluations that assessed the cost-effectiveness of repeated latent tuberculosis infection screening in workers of health care settings).

## Context and Policy Issues

Despite a low incidence of tuberculosis (TB) in the general population of many countries, the risk of contracting and/or transmitting the disease remains higher in some occupational settings — particularly health care. Health care workers (HCWs) may be serially screened for TB, although the optimal frequency for cost-effectiveness of serial testing for HCWs remains uncertain.

In June 2020, CADTH searched the literature for evidence describing the clinical utility, cost-effectiveness, and evidence-based guidelines concerning serial testing for latent tuberculosis infection (LTBI) in people with a risk of occupational exposure to TB.[3] That report identified 2 economic evaluations and 3 evidence-based guidelines.[3]

The purpose of the current report is to summarize and critically appraise the economic evaluations identified previously[4-6] to assess the cost-effectiveness of occupational screening for LTBI infection.

This report is a component of a larger condition-level review on TB. A CADTH condition-level review involves the identification, assessment, and summary of available evidence specific to a particular health condition, including describing disease prevention, diagnosis, treatment, and management. To learn more about CADTH's condition-level review describing evidence on TB, please visit https://www.cadth.ca/tuberculosis.

## Research Question

- What is the cost-effectiveness of serial testing for latent tuberculosis infection in people with a risk of occupational exposure to tuberculosis?

## Methods

### Literature Search Methods

A limited literature search was conducted by an information specialist for a previous CADTH report,[3] including key resources (i.e., MEDLINE via Ovid, the Cochrane Library, the University of York Centre for Reviews and Dissemination (CRD) databases, the websites of Canadian and major international health technology agencies, as well as a focused internet search. The search strategy comprised both controlled vocabulary, such as the National Library of Medicine's MeSH (Medical Subject Headings), and keywords. The main search concepts were tuberculosis testing and occupational testing. No filters were applied to limit the retrieval by study type. The search was also limited to English-language documents published between January 1, 2015 and June 1, 2020. Internet links were provided, where available.

## Selection Criteria and Methods

The evidence in this report was identified in a previous CADTH report,[3] for which 1 reviewer screened citations and abstracts. For the current report, the full-text articles were retrieved and reviewed by 1 reviewer and the final selection of full-text articles was based on the inclusion criteria presented in Table 1.

## Exclusion Criteria

Articles were excluded if they did not meet the selection criteria outlined in Table 1, were duplicate publications, or were published before 2015.

## Critical Appraisal of Individual Studies

The included publications were critically appraised by 1 reviewer using the Drummond checklist for assessing economic evaluations.[7] Summary scores were not calculated; rather, the strengths and limitations of each included study are described narratively.

# Summary of Evidence

## Quantity of Research Available

In the previous CADTH report,[8] a total of 462 citations were identified in the literature search and 5 potentially relevant publications were retrieved from the grey literature. Fourteen potentially relevant reports were identified and retrieved for full-text review, of which 2 economic evaluations[4,5] met the inclusion criteria and were included in this report.

### Table 1: Selection Criteria

| Criteria | Description |
| --- | --- |
| **Population** | People with potential occupational exposure to tuberculosis (e.g., health care workers, staff in long-term care facilities, staff in prisons) |
| **Intervention** | Serial testing for latent tuberculosis infection |
| **Comparator** | Testing for latent tuberculosis infection at baseline or post-exposure; no testing for latent tuberculosis infection |
| **Outcomes** | Cost-effectiveness (cost per health benefit) |
| **Study Designs** | Health technology assessments, systematic reviews, economic evaluations |

## Summary of Study Characteristics

Both economic evaluations employed the use of cost-effectiveness analyses[4,5] and the study by Png and colleagues additionally performed a budget impact analysis.[4] Both studies used decision tree models incorporating data describing HCWs as the population of interest.[4,5] Whereas the study by Mullie and colleagues used a health systems perspective, Png and colleagues used a tertiary hospital perspective.[4,5]

Png and colleagues considered a 3-year time horizon comparing a series of potentially feasible screening strategies in a Singaporean context — including various combinations of serial screening strategies (i.e., annual and triennial), together with screening for new and/or all HCWs — against a no-screening alternative, which was reported as the status quo at the time when the study was reported.[4] The study assumed the use of only 1 type of test, the QuantiFERON-TB Gold In-Tube (QFT) test. This was because of the reported potential for compromised interpretation of the TB skin test (TST) owing to a particular childhood vaccine in the Singaporean schedule that may interfere with the accuracy of the TST.[4] The hypothetical cohort of HCWs was reported as being 30 years of age and included 5,000 individuals working on the front lines of health care. Data sources included published literature, expert opinion, and hospital-based information.[4] The study sought to describe cost-effectiveness using measures including active TB cases and quality-adjusted life-years (QALYs), with costs calculated in Singaporean dollars and converted to US dollars using a 3% discount rate for the cost-effectiveness analysis. Key assumptions in the model included a 9-to-1ratio of Singaporean to international HCWs, high-risk and low-risk categories among HCWs, the sensitivity and specificity of the QFT test, negative chest X-rays at each time point measurement, a consistent level of risk across the time horizon, adherence to treatment for those identified with LTBI; and no deaths, transmission, or recurrence of TB across the time horizon.[4] The budget impact analysis (BIA) included a similar set of assumptions but also assumed a 10% turnover rate of HCW staff across the time horizon.[4]

Mullie et al. used a 20-year time horizon in a Canadian context, using 3 screening approaches with 2 types of tests across both low- and high-risk scenarios, for a total of 12 unique screening strategies.[5] The screening included a serial, mixed serial, and non-serial approach (i.e., annual, once per year, for all HCWs); targeted (annual for high-risk HCWs and post-exposure-only for other HCWs), and post-exposure (post-exposure, only, for all HCWs). The test types assessed were the TST or the QFT; and low- and high-risk statuses for exposure to TB among HCWs were defined using published clinical data.[5] The hypothetical cohort of 1,000 HCWs had a mean age of 35 years and was assumed to be 80% female.[5] Cost-effectiveness was assessed using TB cases, costs of the screening programs, QALYs, mortality, and measures of test performance, with clinical and cost data drawn from published literature using 2015 Canadian dollars and a 3% discount rate.[5] Key assumptions in the models included a negative baseline test for TB for all HCWs, diagnosis of all active TB cases, a consistent level of risk for acquiring TB across the time horizon (despite the actual level of risk likely being variable), 100% compliance with testing protocols, 75% identification of exposures, and treatment for all active TB cases.[5]

Additional details describing study characteristics are tabulated in Appendix 1.

## Summary of Critical Appraisal

Both of the economic evaluations included in this report demonstrated strengths and limitations.[4,5] With regard to the study design, key details were clearly reported by both studies, including the research hypotheses, their economic importance, the chosen viewpoints for the analyses, the type of economic evaluations being used, and the alternative interventions being compared.[4,5] However, neither study provided an explicit justification for the viewpoints selected, the alternative interventions chosen, or the type of economic evaluation selected.[4,5]

Similarly, parameters of effective data collection indicated both strengths and limitations in both studies; whereas primary outcomes and methods for valuing benefits and estimating quantities and costs were included in both studies, details describing the sources used to inform estimates — including information regarding the study design, populations, and results from these sources — were not provided by either study.[4,5] And whereas currency and price information were clearly provided by both studies, details describing productivity changes and quantities of resources (separate from costs) were not reported by either study.[4,5] Though, while Png and colleagues described details of their model — including a justification for key parameters selected[4] — the paper by Mullie and colleagues did not explicitly provide this information.[5]

As it concerns the analysis and interpretation reported, both studies included critical information describing the time horizon, discount rate, sensitivity, and incremental analyses, as well as a description of the study's limitations and conclusions that followed from the research hypotheses.[4,5] However, while both studies failed to provide detail describing the use of statistical tests and/or confidence intervals,[4,5] the report by Mullie and colleagues also failed to provide a justification for the selected discount rate, as well as a justification for the variables and ranges chosen to inform the sensitivity analyses.[5] Further, the evaluation by and colleagues did not report major outcomes in both an aggregated and disaggregated format.[5]

Additional details describing critical appraisal are tabulated in Appendix 2.

## Summary of Findings

### Cost-Effectiveness of Occupational Screening for Latent Tuberculosis Infection

Png and colleagues report that all of the screening strategies modelled were found to be cost-effective when compared to the no-screening status quo and in consideration of a US$50,000 willingness-to-pay threshold, although some strategies rendered more favourable scenarios than others.[4] Study authors reported that a combined and targeted strategy of screening new hires plus triennial screening for existing, high-risk HCWs was found to be the most cost-effective, rendering an incremental cost-effectiveness ratio (ICER) value of US$58 per QALY, a cost of US$6,745 per case of TB avoided, and reducing the number of expected TB cases from 19 to 14 across the 3-year time horizon when compared to the no-screening status quo.[4] The strategy involving the screening for all new hires plus the annual screening for all HCWs was reported to be the most costly, with an ICER value of US$311 per QALY and a cost of US$26,646 per case of TB avoided. But this strategy rendered the largest reduction in expected TB cases from 19 to 6 across the study time horizon as compared to the no-screening approach.[4] The authors reported finding that the least cost-effective strategies were those that:

- screen all new HCWs triennially upon their hire (i.e., an ICER of US$122 per QALY at a cost of US$53,926 per TB case avoided and a reduction in expected TB cases from 19 to 18)

- screening new international hires and high-risk HCWs on an annual basis (i.e., an ICER of $157 at a cost of US$21,482 per TB case avoided and a reduction in expected TB cases from 19 to 13).[4]

These 2 strategies were considered dominated by the study authors and removed from further analyses.[4] The cost-effectiveness analysis indicated that the cost of the QFT test accounted for the largest proportion of overall costs calculated.[4] Data from the BIA were not available, but authors reported that the findings from the sensitivity analyses indicated that observations were most sensitive to changes in the number of HCWs and the rate of staff retention.[4]

Mullie and colleagues reported that all 6 of the screening strategies modelled using the QFT test were less cost-effective when compared to the 6 TST screening strategies; i.e., they were significantly more costly, with no appreciable added benefit, and had higher rates of false-positive test results. Using the TST across the 20-year time horizon, annual screening strategies were found to be less cost-effective than targeted or post-exposure approaches; i.e., in the base-case analysis, the total cost of the annual screening approach was CA$404,956, with 2.68 TB cases identified per 1,000 HCWs. This compared to a total cost of CA$151,517 and 2.83 TB cases identified per 1,000 HCWs using the targeted strategy and producing an incremental cost per additional TB case avoided of CA$1,717,539 for the annual as compared to the targeted screening strategy.[5] In comparison with the targeted strategy, the total cost for the post-exposure screening strategy was CA$198,480, with 3.03 TB cases identified per 1,000 HCWs, producing an incremental cost of CA$426,678 per additional TB case avoided using the targeted strategy.[5] In the alternate scenario analyses, the total cost of the annual screening approach using TST was CA$487,837, with 7.64 TB cases identified per 1,000 HCWs. This compared to a total cost of CA$257,670 and 8.18 TB cases identified per 1,000 HCWs using the targeted strategy and producing an incremental cost per additional TB case avoided of CA$426,678 for the annual as compared to the targeted screening strategy.[5] The total cost for the post-exposure screening strategy with TST was CA$198,480, with 8.90 TB cases identified per 1,000 HCWs, resulting in an incremental cost per additional TB case avoided of CA$52,552 for the targeted as compared to the post-exposure strategy.[5] The authors noted that there were no significant differences among any of the screening strategies with regard to mortality — either resulting from active TB or treatments administered for active TB or LTBI.[5]

Additional details describing study findings are tabulated in Appendix 3.

## Limitations

This report is limited by the amount of evidence identified describing the cost-effectiveness of occupational screening for LTBI; i.e., 2 economic evaluations demonstrating both strengths and limitations were found to be eligible and have been described herein. While this report sought information on occupational screening in general, the eligible studies identified assessed screening only in the health care occupational settings,[4,5] with no eligible studies found describing the cost-effectiveness of screening in other occupational settings (e.g., correctional facilities).

Of the 2 economic evaluations, 1 bears clear applicability to the Canadian context,[5] while the other has limited applicability, given the objectives and assumptions informing those analyses (e.g., the health care human resources, risk probabilities, and current approaches to screening for LTBI in occupational settings), which are not comparable to those in Canada.[4] And though the study reported by Mullie and colleagues provides information applicable to the Canadian context, the critical appraisal identified some missing details that would inform a more robust assessment of its utility in various settings across Canadian health jurisdictions.[5]

As with all economic models (and other mathematical models, in general), the accuracy of the estimates reported are limited by the extent to which the input variables are consistent with real-world circumstances in a particular context, and so are subject to a potential for at least some threshold of error.[9]

## Conclusions

Two economic evaluations[4,5] were identified by an earlier CADTH report,[3] then summarized and critically appraised in this report. Both studies assessed the cost-effectiveness of screening for LTBI in HCWs using either a hospital perspective[4] or a health systems perspective.[5] No evidence was identified assessing the cost-effectiveness of screening for LTBI in other occupational settings (e.g., corrections facilities).

Notably, the 2 studies included and described in this report were conducted within very different health system and societal contexts (i.e., Singapore and Canada), with different risk profiles for TB that affect both the general population and HCWs: whereas Singapore is described as a country with an intermediate burden of TB,[4] Canada is described as a low-risk country for TB.[5] These macro-level risks are important considerations when assessing the applicability of the evidence that has been generated, as the cost-effectiveness estimates produced using a Canadian health systems approach are likely to have greater utility in the Canadian context.

In general, the 2 economic evaluations assessed by this review reported that serial approaches to health care occupational screening for LTBI are likely to be more costly, less beneficial, and therefore less cost-effective than those that are more targeted.[4,5] While the current approaches to occupational screening for LTBI in Canada vary across settings and jurisdictions,[10-12] current guidance specific to health care occupational settings at the federal level from the Public Health Agency of Canada recommends screening for new HCWs and either serial or targeted screening approaches thereafter, depending on the level of risk and other contextual factors.[13] And whereas the cost-effectiveness evidence identified for this report and applicable to the Canadian context is limited, considered alongside these current recommendations, an assessment of risk and a tailored screening strategy are likely to be important measures for ensuring an optimally cost-effective approach to occupational health care screening for LTBI in any particular health care setting in Canada.

While more research may benefit the accuracy of estimates of cost-effectiveness for occupational LTBI screening, tailored approaches to assessing cost-effectiveness that are specific to particular occupational settings and use a combination of local and population-level data are likely to be optimal.

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# Appendix 1: Characteristics of Included Publications

## Table 2: Characteristics of Included Economic Evaluations

| Study citation country, funding source | Type of analysis, time horizon, perspective | Population characteristics | Intervention and comparator(s) | Approach | Source of clinical, cost, and utility data used in analysis | Main assumptions |
|---|---|---|---|---|---|---|
| **Png et al. (2019)**[4]<br>**Country: Singapore**<br>**Funding: Reported as none** | **Analysis type:** cost-effectiveness and budget impact analysis<br>**Time horizon:** 3yrs<br>**Perspective:** Tertiary care hospital | **Population:** 5,000 frontline Singaporean HCWs<br>**Age:** 30yrs<br>**Sex:** NR | **Interventions:**<br>• New: Triennial screening for all new hires (using QFT)<br>• New int'l + triennial high risk: Screening for new International hires and triennial screening for high-risk HCWs (using QFT)<br>• New int'l + annual high-risk: Screening for new International hires and annual screening for high-risk HCWs (using QFT)<br>• New + triennial universal: Screening for all new hires and triennial screening for all HCWs (using QFT) | Decision analysis model using TreeAge software<br>BIA using MS Excel<br>**Outcomes:**<br>• Active TB cases<br>• QALYs<br>Costs in 2016 Singaporean dollars converted to 2016 USD using a 3% discount rate and considering $50,000 as the willingness-to-pay/ cost-effectiveness threshold; BIA used undiscounted costs | **Clinical data sources:** published literature, expert opinion and hospital-based data<br>**Cost data:** Hospital-based data<br>**Utility data:** NR | • **CEA:**<br>• Existing HCWs categorized as working in high-risk or low-risk areas<br>• Newly hired HCWs categorized as Singaporean or International<br>• HCWs had negative chest X-rays at each screening time point<br>• HCWs with LTBI would be adherent to treatment<br>• No deaths and no transmissions or recurrent TB<br>• Consistent level of risk across the time horizon<br>**BIA:**<br>• As per the CEA but also a dynamic cohort with 10% turnover rate |

| Study citation country, funding source | Type of analysis, time horizon, perspective | Population characteristics | Intervention and comparator(s) | Approach | Source of clinical, cost, and utility data used in analysis | Main assumptions |
|---|---|---|---|---|---|---|
| | | | • New + triennial universal + annual high-risk: Screening for all new hires, triennial screening for all HCWs and annual screening for high-risk HCWs (using QFT)<br>• New + annual universal: Screening for all new hires and annual screening for all HCWs (using QFT)<br>**Comparator:** no screening | Sensitivity analyses:<br>• One-way sensitivity analyses performed by varying parameter values across plausible ranges<br>• Probabilistic sensitivity analysis using Monte Carlo simulations | | |
| **Mullie et al. (2017)**[5]<br>**Country: Canada**<br>**Funding sources: McGill University; Canadian Institutes for Health Research** | • **Analysis type:** cost-effectiveness<br>• **Time horizon:** 20yrs<br>• **Perspective:** Health care system | • **Population:** HCWs at risk of developing TB infection (N = 1,000)<br>• **Mean age:** 35yrs<br>• **Sex:** 80% female | • **Intervention:** Annual screening for all HCWs (using either TST or QFT)<br>• **Comparators:**<br>• Targeted screening i.e., annual for high-risk HCWs and post-exposure only for other HCWs (using either TST or QFT)<br>• Post-exposure screening for all HCWs (using either TST or QFT) | Decision analysis model using TreeAge software<br>**Outcomes:**<br>• Costs<br>• Cases<br>• TB QALYs<br>• Mortality<br>• Test performance<br>Costs in 2015 Canadian dollars using a 3% discount rate | **Clinical data source:** US- and Italian-based data from across a 30yr timespan considering both higher- and lower-risk scenarios<br>**Cost data source:** published North American values<br>**Utility data source:** NR | All HCWs had a negative baseline test<br>Base case assumptions:<br>• High-risk HCWs had a 1.0% annual risk of acquiring TB<br>• Intermediate-risk HCWs had a 0.3% annual risk of acquiring TB<br>• 75% of exposures were identified<br>• HCWs 100% compliant with annual testing protocols<br>• All active TB identified and treated |

| Study citation country, funding source | Type of analysis, time horizon, perspective | Population characteristics | Intervention and comparator(s) | Approach | Source of clinical, cost, and utility data used in analysis | Main assumptions |
|---|---|---|---|---|---|---|
| | | | | Sensitivity analyses:<br>• One-way sensitivity analyses performed by varying parameter values across plausible ranges<br>• Tornado analyses performed to assess relative impact of variability across model inputs<br>• Two-way sensitivity analyses combining selected model inputs | | |

BIA = budget impact analysis; CEA = cost-effectiveness analysis; HCW = health care worker; ICER = incremental cost-effectiveness ratio; LTBI = latent tuberculosis infection; NR = not reported; QALY = quality-adjusted life-year; QFT = Quantiferon-TB Gold-In-Tube test; TB = tuberculosis; TST = tuberculosis skin test; USD = US dollars; yrs = years.

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# Appendix 2: Critical Appraisal of Included Publications

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## Table 3: Strengths and Limitations of Economic Evaluations Using the Drummond Checklist[7]

| Strengths | Limitations |
|---|---|
| **Png et al. (2019)[4]** | |
| **Study design**<br>• The research hypothesis and its economic importance are clear<br>• The viewpoint of the analysis is clearly stated<br>• The type of economic evaluation and the alternatives being compared are clearly reported<br>**Data collection**<br>• Sources for estimates for effectiveness are clearly provided<br>• Primary outcome measures are stated<br>• Methods to value benefits are stated<br>• Methods for the estimation of quantities and costs are stated<br>• Currency and price information are included, including details regarding currency conversion<br>• Details describing the model used are provided, including justification for the key parameters selected<br>**Analysis and interpretation**<br>• The time horizon, discount rate and its justification are included<br>• Sensitivity analyses, including variables and ranges selected, are described<br>• Incremental analyses are reported and relevant alternatives are compared<br>• Major outcomes are reported both in aggregate and disaggregate format<br>• The research hypothesis is addressed and conclusions reflect the data reported, including a description of study limitations | **Study design**<br>• A justification for the selected viewpoint of the analysis is not provided<br>• The rationale for selecting alternative interventions is not explicitly provided<br>• The chosen type of economic evaluation is not explicitly justified vis-à-vis the research hypothesis being addressed<br>**Data collection**<br>• Details describing the design and results of the studies from which effectiveness estimates were sourced are not provided<br>• Details describing the subjects from whom valuations were ascertained are not provided<br>• Productivity changes are not described in detail nor are results reported separately<br>• The relevance of productivity changes to the research hypothesis is not clearly described<br>• Quantities of resource use are not reported separately from their unit costs<br>**Analysis and interpretation**<br>• Details describing statistical tests and confidence intervals are not described |

| Strengths | Limitations |
| --- | --- |
| **Mullie et al. (2017)[5]** | |
| **Study design**<br>• The research hypothesis and its economic importance are clear<br>• The viewpoint of the analysis is clearly stated<br>• The type of economic evaluation and the alternatives being compared are clearly reported<br>**Data collection**<br>• Primary outcome measures are stated<br>• Methods to value benefits are stated<br>• Methods for the estimation of quantities and costs are stated<br>• Currency and price information are included, including details regarding currency conversion<br>**Analysis and interpretation**<br>• The time horizon and discount rate are stated<br>• Sensitivity analyses are described<br>• Incremental analyses are reported and relevant alternatives are compared<br>• The research hypothesis is addressed and conclusions reflect the data reported, including a description of study limitations | **Study design**<br>• A justification for the selected viewpoint of the analysis is not provided<br>• The rationale for selecting alternative interventions is not explicitly provided<br>• The chosen type of economic evaluation is not explicitly justified vis-à-vis the research hypothesis being addressed<br>**Data collection**<br>• Sources for estimates for effectiveness are only referenced and not otherwise described<br>• Productivity changes are not described in detail nor are results reported separately<br>• The relevance of productivity changes to the research hypothesis is not clearly described<br>• Quantities of resource use are not reported separately from their unit costs<br>• No explicit justification is provided describing the choice of the model used and the key parameters selected for inclusion<br>**Analysis and interpretation**<br>• No explicit justification for the selected discount rate is provided<br>• Details describing statistical tests and confidence intervals are not described<br>• No explicit justification for the selected variables and ranges informing sensitivity analyses are provided<br>• Major outcomes are not reported both in aggregate and disaggregate format |

# Appendix 3: Main Study Findings and Authors' Conclusions

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## Summary of Findings of Included Economic Evaluations

### Png et al. (2019)[4]

#### Main Study Findings

**Base Case (per 5,000 HCWs across 3 years using QFT exclusively)**

- **New**
  - TB cases (Number [N])
    - 18
  - TB cases averted (N)
    - 1
  - Cost per HCW (USD)
    - 55
  - Incremental cost (US dollars)
    - 9
  - Incremental cost/TB case averted (US dollars)
    - 53,926
  - QALYs per HCW
    - 2.98
  - Incremental QALYs
    - 0.07
  - ICER (US dollars/QALY)
    - 122
- **New international + triennial high-risk**
  - TB cases (N)
    - 14
  - TB cases averted (N)
    - 5
  - Cost per HCW (US dollars)
    - 53
  - Incremental cost (US dollars)
    - 7
  - Incremental cost/TB case averted (US dollars)
    - 6,745
  - QALYs per HCW
    - 3.03
  - Incremental QALYs
    - 0.12

- ICER (US dollars/QALY)
  - 58
- **New international + annual high-risk**
  - TB cases (N)
    - 13
  - TB cases averted (N)
    - 6
  - Cost per HCW (US dollars)
    - 70
  - Incremental cost (US dollars)
    - 24
  - Incremental cost/TB case averted (US dollars)
    - 21,482
  - QALYs per HCW
    - 3.07
  - Incremental QALYs
    - 0.15
  - ICER (US dollars/QALY)
    - 157
- **New + triennial universal**
  - TB cases (N)
    - 7
  - TB cases averted (N)
    - 12
  - Cost per HCW (US dollars)
    - 86
  - Incremental cost (US dollars)
    - 40
  - Incremental cost/TB case averted (US dollars)
    - 16,298
  - QALYs per HCW
    - 3.09
  - Incremental QALYs
    - 0.18
  - ICER (US dollars/QALY)
    - 223
- **New + triennial universal + annual high-risk**
  - TB cases (N)
    - 6
  - TB cases averted (N)

        - 13
    - Cost per HCW (US dollars)
        - 103
    - Incremental cost (US dollars)
        - 57
    - Incremental cost/TB case averted (US dollars)
        - 22,657
    - QALYs per HCW
        - 3.12
    - Incremental QALYs
        - 0.21
    - ICER (US dollars/QALY)
        - 275
- **New + annual universal**
    - TB cases (N)
        - 6
    - TB cases averted (N)
        - 13
    - Cost per HCW (US dollars)
        - 113
    - Incremental cost (US dollars)
        - 67
    - Incremental cost/TB case averted (US dollars)
        - 26,646
    - QALYs per HCW
        - 3.13
    - Incremental QALYs
        - 0.22
    - ICER (USD/QALY)
        - 311
- **No screening**
    - TB cases (N)
        - 19
    - TB cases averted (N)
        - Not applicable (N/A)
    - Cost per HCW (US dollars)
        - 46
    - Incremental cost (US dollars)
        - N/A
    - Incremental cost/TB case averted (US dollars)

- N/A
  - QALYs per HCW
    - 2.91
  - Incremental QALYs
    - N/A
  - ICER (USD/QALY)
    - N/A

**Authors' Conclusion**

"Targeted LTBI screening for HCWs can be highly cost-effective for hospitals in settings similar to Singapore. More inclusive screening strategies (including regular universal screening) can yield better outcomes but are less efficient and may even be unaffordable." (p. 341)

## Mullie et al. (2017)[5]

### Main Study Findings

**Base Case (per 1,000 HCWs across 20 years)**

- **Annual screening**
  - New active cases
    - TST
      - 2.68
    - QFT
      - 2.80
  - Cost (Canadian dollars)
    - TST
      - 404,956
    - QFT
      - 817,695
  - QALYs
    - TST
      - 15,231.85
    - QFT
      - 15,227.92
  - ICER (per additional TB case prevented)
    - TST
      - $1,717,539
  - Active TB-related mortality
    - TST
      - 0.12
    - QFT
      - 0.12
  - TB treatment-related mortality:  Active

        - TST
            - 0.0020
        - QFT
            - 0.0021
    - TB treatment-related mortality: Latent
        - TST
            - 0.00258
        - QFT
            - 0.00362
    - Test performance: True-positive results
        - TST
            - 75
        - QFT
            - 64
    - Test performance: False-positives
        - TST
            - 413
        - QFT
            - 607
- **Targeted screening**
    - New active cases
        - TST
            - 2.83
        - QFT
            - 2.86
    - Cost (Canadian dollars)
        - TST
            - 151,517
        - QFT
            - 263,660
    - QALYs
        - TST
            - 15,237.96
        - QFT
            - 15,236.90
    - ICER (per additional TB case prevented)
        - TST
            - $517,437
    - Active TB-related mortality
        - TST

- 0.36
- QFT
  - 0.36
- TB treatment-related mortality: Active
  - TST
    - 0.0063
  - QFT
    - 0.0063
- TB treatment-related mortality: Latent
  - TST
    - 0.00152
  - QFT
    - 0.00177
- Test performance: True-positive results
  - TST
    - 193
  - QFT
    - 184
- Test performance: False-positive results
  - TST
    - 96
  - QFT
    - 146

- **Post-exposure screening**
  - New active cases
    - TST
      - 8.90
    - QFT
      - 8.73
  - Cost (Canadian dollars)
    - TST
      - 198,480
    - QFT
      - 228,809
  - QALYs
    - TST
      - 15,234.05
    - QFT
      - 15,233.75
  - ICER (per additional TB case prevented)

- QFT
  - $197,017
- Active TB-related mortality
  - TST
    - 0.13
  - QFT
    - 0.13
- TB treatment-related mortality: Active
  - TST
    - 0.0023
  - QFT
    - 0.0023
- TB treatment-related mortality: Latent
  - TST
    - 0.00036
  - QFT
    - 0.00040
- Test performance: True-positive results
  - TST
    - 63
  - QFT
    - 67
- Test performance: False-positive results
  - TST
    - 6
  - QFT
    - 11

**Alternate scenario (per 1,000 HCWs across 20 years)**

- **Annual screening**
  - New active cases
    - TST
      - 7.64
    - QFT
      - 7.95
  - Cost (Canadian dollars)
    - TST
      - 487,837
    - QFT
      - 868,662
  - QALYs

    - TST
        - 15,227.38
    - QFT
        - 15,223.94
  - ICER (per additional TB case prevented)
    - TST
        - $426,678
  - Active TB-related mortality
    - TST
        - 0.33
    - QFT
        - 0.35
  - TB treatment-related mortality: Active
    - TST
        - 0.0058
    - QFT
        - 0.0061
  - TB treatment-related mortality: Latent
    - TST
        - 0.00307
    - QFT
        - 0.00395
  - Test performance: True-positive results
    - TST
        - 203
    - QFT
        - 174
  - Test performance: False-positive results
    - TST
        - 373
    - QFT
        - 553
- **Targeted screening**
  - New active cases
    - TST
        - 8.18
    - QFT
        - 8.23
  - Cost (Canadian dollars)
    - TST

- 257,670
  - QFT
    - 365,397
- QALYs
  - TST
    - 15,232.84
  - QFT
    - 15,231.90
- ICER (per additional TB case prevented)
  - TST
    - $52,552
- Active TB-related mortality
  - TST
    - 0.36
  - QFT
    - 0.36
- TB treatment-related mortality: Active
  - TST
    - 0.0063
  - QFT
    - 0.0063
- TB treatment-related mortality: Latent
  - TST
    - 0.00152
  - QFT
    - 0.00177
- Test performance: True-positive results
  - TST
    - 193
  - QFT
    - 184
- Test performance: False-positive results
  - TST
    - 96
  - QFT
    - 146

- **Post-exposure screening**
  - New active cases
    - TST
      - 8.90

- QFT
  - 8.73
- Cost (Canadian dollars)
  - TST
    - 198,480
  - QFT
    - 228,809
- QALYs
  - TST
    - 15,234.05
  - QFT
    - 15,233.75
- ICER (per additional TB case prevented)
  - QFT
    - Extended dominance (ICER, otherwise not reported)
- Active TB-related mortality
  - TST
    - 0.39
  - QFT
    - 0.38
- TB treatment-related mortality: Active
  - TST
    - 0.0068
  - QFT
    - 0.0067
- TB treatment-related mortality: Latent
  - TST
    - 0.00109
  - QFT
    - 0.00119
- Test performance: True-positive results
  - TST
    - 195
  - QFT
    - 201
- Test performance: False-positive results
  - TST
    - 17
  - QFT
    - 30

## Authors' Conclusion

"For most North American healthcare workers, annual tuberculosis screening appears poorly cost-effective. Reconsideration of screening practices is warranted." (p. 1 of 15)